



Product Safety, Buybacks and the Post-Sale Duty to Warn

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PRODUCT SAFETY, BUYBACKS AND THE POST-SALE DUTY TO WARN

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Kathryn E. Spier¹

Abstract: A manufacturer learns a product's risks after it has been sold and distributed to consumers. When held strictly liable for product-related injuries, the manufacturer offers to repurchase the product when the risk exceeds a threshold. Consumers accept the offer when their private valuations of consumption are smaller than the buyback price. The manufacturer's private incentives to stage a buyback are insufficient, the buyback price offered is too low, and the continued product usage by consumers is excessive. The ability of the manufacturer to repurchase the product *ex post* reduces the incentive to design safer products *ex ante*. A negligence rule, the "post-sale duty to warn," implements the social welfare benchmark.

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1. Introduction

In the summer of 2000, Williams-Sonoma learned that the small propane gas grills that they had been selling through their stores, their catalog, and the internet were defective.² Although no injuries had occurred, two customers reported that they had been unable to turn off the flow of the propane gas, suggesting a serious risk of a fire or an explosion. Using its own electronic credit card records and enlisting the help of credit card companies, Williams-Sonoma contacted the nearly 1000 customers who had purchased the grill, offering a full refund of the \$200 purchase price plus a \$50 gift certificate.³ All but two of the grills were returned and Williams-Sonoma was publicly lauded for their fast and effective response.⁴

Product recalls have become increasingly common in recent years. In the United States in 2002, one in eleven cars on the road were recalled, a total of almost 19 million automobiles. In 2003, there were more than 5,000 consumer products recalled involving approximately 60 million consumer purchases.⁵ The recall process is overseen by six government agencies: the Food and Drug Administration (FDA), the National Highway and Traffic Safety Administration (NHTSA), the Consumer Product Safety Commission (CPSC), the Department of Agriculture, the Coast Guard, and the Environmental Protection Agency (EPA). While many of the recalls

² Williams-Sonoma, Inc. is a specialty retailer in the United States. Williams-Sonoma began in 1956 by importing high-quality pots and pans from France. More recently, they have expanded to selling small electric appliances, tableware, cookbooks, and specialty foods.

³ See Finley (2002a), Consumer Reports (2004), and the Federal Document Clearing House (2001). They also offered to reimburse shipping charges and to pick up the grills from the customers' homes. M2 Presswire (2000).

⁴ Similarly, in 2005 Starbuck's coffee offered a full refund and a \$5 gift certificate for the return of certain tea kettles that could cause harm to consumers. See Parkin (2006). The example of the BernzOMatic Company stands in contrast to these success stories. The BernzOMatic Company initiated a recall of their low-budget gas heaters in 1987. Tragically, almost forty people had already died from its carbon monoxide emissions. Despite offering \$250 for the return of the heaters that originally were sold for just \$35, it is estimated that over 7,000 of the 40,000 heaters sold still remain in household use. See Finley (2002a).

⁵ See Consumer Reports (2004). Most of these products remain in use and unfixed. It is estimated that one third of all vehicles subject to recalls are never fixed, and the number of the unrepaired toys, appliances, electronics and car seats is far higher.

instruct consumers to discontinue their use of the product and return it to the retailer or the manufacturer for a refund or a repair, the policies vary. Some recalls are simply warnings to consumers to limit their use of products.⁶ Others supplement their warnings with recommended consumer actions, such as removing or disabling a hazardous part of the product.⁷

This paper considers the problem faced by a manufacturer who learns the propensity of a product to harm consumers only after the product has been sold and distributed to customers. In the post-sale stage, the privately-informed manufacturer must decide whether to contact previous customers to warn them of the impending risks and whether to solicit the return of the product. Recalls are costly, however – contacting consumers and repurchasing the product only makes financial sense when the benefits are large.⁸ This paper considers the effect of strict liability on the manufacturer's post-sale decision to recall the product from the market and on the *ex ante* incentive to design safer products to begin with. A negligence-based rule, the "post-sale duty to warn," is also considered.

New information about the risks posed by previously-sold products is socially valuable because of its potential to change consumer behavior. Suppose the previously-sold product is discovered to be more dangerous than originally expected. In this case, some consumers who might otherwise have continued to use the product (based upon the prior beliefs) should in fact discontinue their use.⁹ On the flip side, if the product is discovered to be unusually safe – much safer than expected – then some consumers who might otherwise have stopped using the product should resume using it. In general, the socially optimal policy features disclosure of product risks at the two extremes: when the product is especially dangerous and when the product is unusually safe. Assuming that the expected product risk is fairly small to begin with, and that the bulk of consumers derive sufficient value from using the product, allows us to restrict attention to the former case. This generates a realistic social welfare benchmark where

⁶ See, for example, "CPSC Warns of Choking Hazard from Halloween Pumpkin Erasers," CPSC Release # 95-018.

⁷ See, for example, "Baby Cookie Monster Toys Sold with DVD at Wal-Mart Recalled for Choking Hazard," CPSC Release #07-009.

⁸ In the words Marty Richmond, the spokesman of Furniture Brands International, the parent company of Lane and Broyhill among others, "Simply getting the consumer to recognize the threat and making them pick up the phone is hands down the most difficult." Finley (2002b).

⁹ If the product is extremely dangerous – causing death with certainty for example – then the product should be totally withdrawn from the market. More generally, however, consumers with sufficiently high valuations for the product are in a position to bear increased levels of risk.

consumers are warned when (and only when) the product is discovered to be particularly hazardous and stop using the product when the risks exceed the private benefit of continued use.

Manufacturer liability for consumer harms is socially valuable in this setting. Without it, the manufacturer would have no *ex post* incentive to warn consumers or to repurchase the product. Consumers would continue to use hazardous products and would suffer the harms. Under strict liability, the manufacturer has an incentive to withdraw hazardous products from the market. The manufacturer privately benefits from a buyback when the price that it pays to repurchase a unit is smaller than the expected future liability associated with that unit.¹⁰ Strict liability does not achieve the social welfare benchmark for two reasons, however. First, the manufacturer is a monopsonist in the post-sale stage and will therefore exercise market power, offering a buyback price that is below the opportunity cost (the expected harm to a consumer). Since the buyback price that the manufacturer offers is too low, the continued product use is excessive.¹¹ Second, the manufacturer will not sink the fixed costs to initiate a recall often enough. Intuitively, consumers with low valuations for the product receive consumer surplus from a recall (since their valuations for continued product use are below the buyback price). The manufacturer only considers his own profit when contemplating a buyback, not the consumer surplus associated with a buyback.

A negligence-based duty to warn that holds the manufacturer responsible for consumer harms if and only if the manufacturer failed to issue a cost-justified warning achieves the social welfare benchmark. Indeed, this rule is consistent with the 1998 *Restatement (Third) of Torts: Products Liability* §10, which imposes a post-sale duty to warn when “a reasonable person in the seller’s position would provide such a warning.” Before the *Restatement* was published by the

¹⁰ This rule is a variant of the familiar rule of strict liability with no defense of contributory negligence. The decision of a consumer to continue to use the product in our setting is analogous to consumer care to avoid accidents in the more traditional setting. A defense of contributory negligence in our model would shift liability to the consumer if the consumer continued to use the product despite having a low private valuation for consumption. In practice, a consumer’s utility for consumption is private information so such a rule would be very hard for a court to enforce. For this reason, the rule of strict liability with a defense of contributory negligence is not formally considered here.

¹¹ We maintain the assumption throughout the paper that the manufacturer cannot commit to a buyback price ahead of time. This is a reasonable assumption when the complexity of the product precludes an accurate *ex ante* forecast of all of the risks that might arise and the propensity for harm.

American Law Institute in 1998, it was uncommon for courts to recognize the post-sale duties of sellers. Since then, however, more than 30 states have adopted some version of it.¹² To apply this rule, the court would need to assess whether “the risk of harm is sufficiently great to justify the burden of providing a warning.”¹³ To do this accurately, the court would need to understand not only the product risks, but also the nature of consumer demand and the costs of contacting consumers and communicating the information effectively. These are heroic assumptions. In contrast, strict liability only requires the court to observe the *ex post* realizations of harms.

We also extend the basic model to include *ex ante* investments by the manufacturer to improve product safety, investments that are assumed to be easily observed by consumers at the time of a sale. When there is no manufacturer liability – so consumers bear all future accident losses *ex post* – the manufacturer has an especially strong *ex ante* incentive to invest in product safety. Consumers, knowing that they won’t be warned of impending harms in the future, are willing to pay a large premium for safer products *ex ante*. The *ex ante* safer design of a product effectively serves as a substitute for *ex post* product recalls. The manufacturer’s incentive to invest in product safety is lower under strict liability. Intuitively, the manufacturer’s ability to mitigate the harms of unsafe products through future product buybacks reduces the marginal benefit of safety investments *ex ante*. The manufacturer’s incentive to invest in product safety is lower still under the post-sale duty to warn. Consumers, knowing that they have the chance to mitigate harms in the future after a warning is issued, demand less safety *ex ante*. Nevertheless, the post sale duty to warn creates the highest social value, followed by strict liability, which is followed by no manufacturer liability at all.

There is a sizable empirical literature on product recalls. Jarrell and Peltzman (1985) conduct an events study of the pharmaceutical and automobile industries, looking at the reaction of the stock market to recall announcements. They show that the stock price reaction is much

¹² See the report by the American Bar Association, Ross (2004).

¹³ Subsection (b) of the *Restatement* provides: “A reasonable person in the seller’s position would provide a warning after the time of sale if: (1) the seller knows or reasonably should know that the product poses a substantial risk of harm to persons or property; and (2) those to whom a warning might be provided can be identified and can reasonably be assumed to be unaware of the risk of harm; and (3) a warning can be effectively communicated to and acted on by those to whom a warning might be provided; and (4) the risk of harm is sufficiently great to justify the burden of providing a warning.”

greater, in magnitude, than the direct costs of the recall.¹⁴ Rupp and Taylor (2002) explore empirically why some automobile recalls are initiated by the automobile manufacturer while others are initiated by the NHTSA. In practice, about 80% of automobile recalls are manufacturer-initiated, while only 20% are government-initiated. They show that the manufacturer is more likely to initiate the less expensive recalls, while the government is more likely to initiate larger recalls.¹⁵

There is also a small theoretical literature on product recalls. Marino (1997) considers the design of *involuntary* recall procedures. In his model, the liability system is imperfect and, in the absence of regulatory involvement, the incentives of manufacturers to design safer products would be suboptimal. The threat of an audit, and the impending punishment of an involuntary recall, gives the manufacturer the incentive to design safer products *ex ante*.¹⁶ Marino does not consider information disclosure, buybacks, or the post-sale incentives of manufacturers or consumers. Welling (1991) does consider the incentives of manufacturers to *voluntarily* recall products and warn consumers about product risks. In her model, firms are long-lived and have an incentive to develop reputations for being honest with consumers. Disclosing product defects can boost consumer confidence and stimulate higher future sales. She does not, however, consider product buybacks or the post-sale duties to warn that are considered here.¹⁷

Ben-Shahar (2005) investigates the incentives of a manufacturer to continue selling a dangerous product when consumers are unsuspecting of the harms that they face. The manufacturer's decision to stop selling the product serves as an admission of guilt making victims more likely to sue. When faced with strict liability, manufacturers will keep dangerous products on the market too long to avoid stimulating a flood of lawsuits that wouldn't otherwise

¹⁴ Interestingly, rivals' stock prices were also negatively affected by the recalls, suggesting an industry-wide reduction in demand. But see the critique of Hoffer et. al. (1988).

¹⁵ Hoffer et. al. (1994) show that owners of newer domestic models are more likely to respond to an automobile recall, bringing their cars in for repairs, than owners of older foreign models. Hartman (1987) shows that automobile recalls lead the resale prices of the affected models to fall, while the resale prices of other models were unaffected. While not about recalls, Mathios (2000) explores the impact of disclosure laws on salad dressing sales.

¹⁶ Marino shows that the second-best regulatory mechanism hinges on the degree of competition in the industry and on the efficacy of the liability system.

¹⁷ Welling shows that imposing strict liability on manufacturers when they fail to warn consumers (but not otherwise) implements the social optimum when consumers all face the same level of risk. In our model, strict liability with a warning defense leads to excessive disclosure.

occur.¹⁸ Ben-Shahar doesn't consider the behavior of existing consumers under different liability rules, however, nor does he consider the efficacy of other post-sale actions such as product buybacks.¹⁹

Shavell (1994) and Polinsky and Shavell (2006) consider the costly acquisition and subsequent disclosure of information about product safety by monopolists *prior to a sale*.²⁰ Manufacturers have a private incentive to disclose favorable information, since higher quality products command higher prices in the market.²¹ Manufacturers who learn that they have relatively unsafe products refrain from disclosing and, in equilibrium, pool with manufacturers who chose not to acquire the information at all. In contrast, the current paper considers information that is discovered after a sale has taken place and the impact that liability rules have on the decision to recall products.

Section 2 presents the basics of the model. Section 3 characterizes a social welfare benchmark. Section 4 analyzes decentralized *ex post* market behavior under three regimes: no manufacturer liability, strict manufacturer liability, and the post-sale duty to warn. Section 5 extends the basic framework to include *ex ante* investments in product safety. Section 6 concludes.

2. The Model

¹⁸ The manufacturer also has socially inadequate incentives to acquire information about product risks. Rule 407 of the Federal Rules of Evidence render the manufacturer's recall decision inadmissible as evidence at trial and restore proper incentives to recall products and acquire information. See Ben-Shahar (2006) for a discussion of the Vioxx case.

¹⁹ Ben Shahar (1998) explores whether liability should be based on information that wasn't known at the time of sale, focusing on *ex ante* incentives rather than the post-sale incentives considered here.

²⁰ This paper is also related to the broader theoretical literature on information disclosure. Milgrom (1981) and Grossman (1981) showed that privately-informed parties would tend to disclose favorable information to avoid adverse inferences from non-disclosure, leading to unraveling. In contrast, Verrecchia (1983) found that partial pooling results when disclosure is costly. Parties with sufficiently unfavorable information pool together, suffering the average adverse inference for the group but saving on disclosure costs.

²¹ See also Dye (1985) for a model of partial pooling in the securities context. In Matthews and Postlewaite (1985) both acquisition and disclosure are costless. Daughety and Reinganum (1995) show that privately informed firms signal their product risks through the prices that they charge. Daughety and Reinganum (2008a) and (2008b) explore the firm's choice between disclosing quality directly and signaling quality through the price.

A potentially harmful product is produced and sold by a manufacturer with unit production cost c . The mass of consumers is normalized to 1. Each consumer uses at most one unit of the good. Consumers are homogeneous at the time of their initial purchase with an expected valuation of v_0 , but learn their idiosyncratic valuations for the product following their purchase.²² A consumer's *gross* valuation for the product is v which is drawn from an integrable density function $g(v)$ which is positive on the support $[\underline{v}, \infty)$ and zero elsewhere.²³ We make the standard assumption that the hazard rate $G(v)/g(v)$ is strictly increasing on $[\underline{v}, \infty)$.²⁴ The consumer's *net* valuation for the product is the gross value less any uncompensated harm or injuries associated with the product's use. The expected harm associated with a unit of the product, h , is drawn from the integrable density $f(h)$ on the support $[0, \infty)$ with mean h_0 . This distribution is assumed to be the same for all buyers and known at the time of sale.

Following the production and sale of the product, the consumers privately learn their valuations, v , and the manufacturer privately observes the level of per unit harm, h . In this post-sale phase, the parties can take actions to mitigate the future losses from product injuries. A consumer can simply stop using the product, foregoing his valuation v .²⁵ The manufacturer can issue a post-sale product warning, disclosing the level of future harm, h , to existing consumers. It is assumed that disclosures are accurate; the manufacturer cannot understate or overstate the accident risks in the product warning. The manufacturer can also make an offer to repurchase the product from consumers for a price p , which is endogenous.²⁶

²² The assumption of *ex ante* homogeneous consumers with unit demand simplifies the analysis. Importantly, there is no *ex ante* deadweight loss from monopoly pricing. Polinsky and Shavell's (2006) analysis of disclosure prior to a sale explicitly takes these distortions into account.

²³ The fact that the distribution is unbounded above implies that some consumers should continue to use the product for any finite product risk. The assumption that the distribution is bounded below facilitates the characterization of the social welfare benchmark and will be discussed in greater detail later.

²⁴ This assumption will imply that the manufacturer's profit function is single peaked, giving a unique and well-behaved buyback price. Many commonly known distributions satisfy this monotone hazard rate assumption, including the normal distribution and the uniform distribution.

²⁵ This framework could be extended to allow for durability, where the consumer consumes the product both before and after learning his preferences.

²⁶ There is a small literature on returns policies when consumers learn their valuations after purchase. In Che (1996), returns policies where consumers can return products at the price paid may be privately and socially desirable in order to avoid inefficient consumption (when a consumer values the product less than the cost of the product) and to avoid unnecessary risk

The parameter $\Delta > 0$ represents any *ex post* fixed costs associated with the product recall. For simplicity, we will assume that these fixed costs are the same for recalls that involve warnings and for those that involve product buybacks.²⁷ These fixed costs would include the costs of identifying and contacting all past purchasers of the product and communicating with them about the nature of the problem. In practice, Δ would include the direct costs of postage and paperwork, the costs of reviewing previous records and registrations, and the transactions costs of coordinating with retailers and distributors (who may have more direct access to information about consumers).²⁸

We will assume throughout the paper that $v_0 - c - h_0 - \Delta > 0$, so it is socially efficient for the product to be produced and sold even when post-sale warnings are routinely issued and consumers continue to use the dangerous product. This assumption, together with our earlier assumption that consumers are *ex ante* identical with unit demand, implies that the different liability rules all lead to the same *ex ante* level of sales. Although the price that the monopolist initially charges for the product would differ under the different liability regimes, all consumers purchase the product, as they should.

3. The Social Welfare Benchmark

Suppose that a social planner could control the manufacturer's decision to disclose the information about product harms (the "disclosure rule") and each individual consumer's decision about whether to continue to use the product (the "consumption rule"). Formally, the disclosure rule partitions the different manufacturer types into two groups, one that discloses product harms

(when consumers are risk averse). In his model, disclosure is irrelevant (because the seller does not learn anything) and the seller can commit to the returns policy *ex ante*. Without commitment, Che's seller would not take returns. In our model, the seller has a private *ex post* incentive to buy back the product to avoid liability payments. Matthews and Persico (2005) consider menus of contracts and consumers' costly acquisition of information.

²⁷ Although there is no publically available data that documents these costs, the *Restatement (Third) of Torts* states that "the costs of identifying and communicating with product users years after sale are often daunting." (*Products Liability* §10 comment a.)

²⁸ In the words of Hal Stratton, the chairman of the CPSC in 2002, "We strive to get zero deaths but there are 280 million people out there ... We can't send a letter to 280 million people. That's cost-prohibitive." As quoted in Finley (2002a). Improvements in technology, namely email and websites, may be reducing these fixed costs. There is a general concern that individuals, overwhelmed by mass mailings and fine print, fail to absorb the meaning.

to consumers (Ω_D) and the other that remains silent (Ω_{ND}). Given the information disclosed, the consumption rule dictates which *ex post* consumer types will be permitted to use the product and which consumers must stop.

More specifically, suppose that $h \in \Omega_D$ so the product harm h is disclosed to consumers at cost Δ . In this case, the social planner's consumption rule can depend on the true level of harm h . The optimal consumption rule would of course allow consumers with sufficiently high valuations ($v \geq h$) to continue to use the product but would require consumers with sufficiently low valuations ($v < h$) to discontinue their use. If $h \in \Omega_{ND}$, on the other hand, we assume that the consumption rule cannot depend on the realized level of harm. It can, however, depend on the *average level of harm* for this group $h_{ND} = E(h|h \in \Omega_{ND})$.²⁹ When harm is not disclosed, the socially optimal consumption rule allows consumers with valuations above the expected harm conditional upon nondisclosure ($v \geq h_{ND}$) to continue to use the product. Consumers with valuations below this level are required to stop.

Taking the socially optimal consumption rule as given, social welfare can be written as a function of the disclosure rule, Ω_D and Ω_{ND} :

$$\int_{\Omega_{ND}} \int_{h_{ND}}^{\infty} (v - h)g(v)f(h)dv dh + \int_{\Omega_D} \int_h^{\infty} (v - h)g(v)f(h)dv dh - \int_{\Omega_D} \Delta f(h)dh - c \quad (1)$$

The first term of equation (1) represents the *ex post* social surplus associated with the set Ω_{ND} . When $h \in \Omega_{ND}$ consumers with valuations $v \geq h_{ND}$ continue to use the product and the social surplus for these consumers $v - h$. The second term of equation (1) is the *ex post* social surplus associated with the set Ω_D . When $h \in \Omega_D$ then consumers with valuations $v \geq h$ continue to use the product (as they should) giving a social surplus of $v - h$. The third term is the expected fixed cost of disclosure and the final term is the cost of production.

Lemma 1 establishes that, in general, the socially optimal decision rule could involve three regions: a middle region where disclosure does not take place (Ω_{ND}) and a high and a low region (together forming Ω_D) where the product risks are disclosed. This is intuitive. Suppose

²⁹ Note that Bayesian consumers would rationally form this expectation following non disclosure.

that $h = h_{ND}$. The optimal consumption rule if harm level $h = h_{ND}$ is disclosed is exactly the same as the rule without disclosure – in both cases, the consumer would be permitted to use the product if and only if $v \geq h_{ND}$. So when $h = h_{ND}$, the social value of disclosure is zero. When the level of risk h is far from h_{ND} , however, then disclosure can significantly change consumer usage behavior and the social value of disclosure is potentially large.

Lemma 1: In general, the socially optimal disclosure rule can involve at most two cutoffs, $\underline{h}(\Delta)$ and $\bar{h}(\Delta)$, where $0 \leq \underline{h}(\Delta) < \bar{h}(\Delta)$, $\Omega_{ND} = [\underline{h}(\Delta), \bar{h}(\Delta)]$ and $\Omega_D = [0, \underline{h}(\Delta)) \cup (\bar{h}(\Delta), \infty)$. Moreover, $\lim_{\Delta \rightarrow 0} [\bar{h}(\Delta) - \underline{h}(\Delta)] = 0$.

Proof: Suppose that Ω_{ND} and Ω_D maximize social welfare. Suppose that the interval $[\hat{h}, \hat{h} + \varepsilon] \subset \Omega_D$. Social welfare would (weakly) fall if this interval were moved from the set Ω_D into the set Ω_{ND} . Using expression (1),

$$\int_{\hat{h}}^{\hat{h}+\varepsilon} \int_{h_{ND}}^{\infty} (v-h)g(v)f(h)dv dh - \int_{\hat{h}}^{\hat{h}+\varepsilon} \int_{\hat{h}}^{\infty} (v-h)g(v)f(h)dv dh + \int_{\hat{h}}^{\hat{h}+\varepsilon} \Delta f(h)dh \leq 0.$$

Dividing by ε and taking the limit as ε approaches zero,

$$\int_{h_{ND}}^{\infty} (v-\hat{h})g(v)f(\hat{h})dv - \int_{\hat{h}}^{\infty} (v-\hat{h})g(v)f(\hat{h})dv + \Delta f(\hat{h}) \leq 0.$$

Dividing by $f(\hat{h})$ and rearranging terms, we have

$$\int_{h_{ND}}^{\infty} (\hat{h}-v)g(v)dv - \int_{\hat{h}}^{\infty} (\hat{h}-v)g(v)dv \geq \Delta. \quad (2)$$

Suppose that $\hat{h} > h_{ND}$. Then expression (2) becomes

$$\int_{h_{ND}}^{\hat{h}} (\hat{h}-v)g(v)dv \geq \Delta.$$

This implies that \hat{h} cannot be too close to h_{ND} . Specifically, there exists a cutoff, $\bar{h}(\Delta) > h_{ND}$, where necessarily $\hat{h} \geq \bar{h}(\Delta)$. Moreover, note that $\bar{h}(\Delta)$ converges to h_{ND} as Δ approaches zero. Now suppose that $\hat{h} < h_{ND}$. We can rewrite expression (2) as

$$\int_{\hat{h}}^{h_{ND}} (v-\hat{h})g(v)dv \geq \Delta.$$

This implies that there exists a cutoff, $\underline{h}(\Delta) < h_{ND}$, where $\hat{h} \leq \underline{h}(\Delta)$. Moreover, note that $\underline{h}(\Delta)$ converges to h_{ND} as Δ approaches zero. This proves that if $[\hat{h}, \hat{h} + \varepsilon] \in \Omega_D$ then $\hat{h} \notin (\underline{h}(\Delta), \bar{h}(\Delta))$. Similarly, one can show that if $[\hat{h}, \hat{h} + \varepsilon] \subset \Omega_{ND}$ then $\hat{h} \in [\underline{h}(\Delta), \bar{h}(\Delta)]$. ■

Requiring a manufacturer to pay large sums of money to contact old consumers to notify them that the products are unusually *safe* is not typical in tort law. In practice, liability may be imposed on manufacturers for failing to warn consumers that products are unusually *dangerous*. This fact is not inconsistent with the model. Analytically, the lowest region described in Lemma 1 disappears when average harm level, h_0 , is sufficiently small. When accidents are rare and expected harms are low from an *ex ante* perspective, then there is very little to be gained from revealing that the product is unusually safe. The following assumption, which we maintain throughout the paper, will guarantee that it is socially desirable to disclose information when the product is especially hazardous but not otherwise.

Assumption 1: $h_0 < \underline{v}$.

Assumption 1 tells us that all consumers – even those who like the product the least – still value the product more than the *ex ante* expected harm, h_0 . This is not unreasonable, especially in light of the fact that these consumers presumably valued the product enough to buy it in the first place.³⁰ More specifically, this assumption implies that there is social value from disclosing product risks when the probability of harm is high but not when the probability of harm is low and gives us a realistic social welfare benchmark.

Proposition 1: (Social Welfare Benchmark). Under Assumption 1, the socially optimal disclosure rule is characterized by a single cutoff, $h^*(\Delta)$, implicitly defined by

$$\int_{\underline{v}}^{h^*(\Delta)} [h^*(\Delta) - v]g(v)dv = \Delta, \quad (3)$$

where $h^*(\Delta)$ is monotonically increasing in Δ with $h^*(0) = \underline{v}$ and $h^*(\Delta) > \Delta$.

³⁰ In reality, some people dislike products and stop using them shortly after purchasing them and never bother to return them. This paper deliberately abstracts from these types of consumers in order to focus instead on the situation where recalls change behavior.

- (i) If $h \leq h^*(\Delta)$ then the harm is not disclosed and all consumers continue to use the product.
- (ii) If $h > h^*(\Delta)$ then the harm is disclosed and only consumers with valuations $v > h$ continue to use the product.

The results in Proposition may be understood intuitively (a formal proof is given in the Appendix). Suppose that the expected future harm is *exactly* at the cutoff, so $h = h^*(\Delta) > \underline{v}$. What is the marginal social benefit of using this piece of information? If the harm is not disclosed, then $h_{ND} < h_0 < \underline{v}$ and all consumers will continue to use the product.³¹ A group of these consumers – namely the ones with valuations in the interval $[\underline{v}, h^*(\Delta)]$ – should in principle discontinue using the product. The marginal social benefit associated with disclosing this harm is that these consumers will stop using the product, saving society $h^*(\Delta) - \underline{v}$. The cutoff $h^*(\Delta)$ in equation (3) is defined to be the level of harm for which the marginal social benefit of disclosing the information to consumers is exactly equal to the marginal social cost of disclosing it, Δ .

When the product risks are very low, $h < \underline{v} = h^*(0)$, then there is no social value to be gained from disclosing h to consumers. The expected harm is negligible compared to the value that the lowest valuation consumer gets from the product. Therefore there is a range, $h \in [0, \underline{v}]$, that are *never disclosed to consumers* in the social welfare benchmark, even when the cost of disclosure is arbitrarily small.³²

4. Liability Rules and *Ex Post* Behavior

³¹ By Proposition 1, $h_{ND} < h_0$. By Assumption 1, $h_0 < \underline{v}$. Therefore $h_{ND} < \underline{v}$ and so no consumers will discontinue using the product.

³² Our assumption that \underline{v} was bounded away from 0 is of course important for this result. If $\underline{v} = 0$ and Δ was arbitrarily small, then the socially optimal decision rule would involve disclosure of both very high and very low harms. (In the limit, all harms except the point $h = h_0$ would be disclosed.) The social welfare benchmark in this case would be unattainable by all realistic liability rules. An alternative modeling strategy, where $\underline{v} = 0$ but Δ is sufficiently bounded away from zero, would yield similar results to those derived here but the restrictions are less intuitive.

No Manufacturer Liability

To start, suppose that the consumers are held fully responsible for their own product-related injuries. It is clear that the manufacturer has no incentive to initiate a recall. Since he faces no liability for consumer injuries, there is nothing to be privately gained from a warning *per se* and there is no incentive to buy the product back.³³ Consumers know this, of course, but believe that the product risks are low on average and continue to use the product. Note that consumers are making the socially correct decisions when they continue to use the product, *conditional upon their lack of information*. The social welfare associated with this regime, $v_0 - h_0 - c > 0$, is lower than the social welfare benchmark since consumers are unable to restrict their usage decisions when the product poses significant hazards.

Strict Manufacturer Liability

Now suppose that the manufacturer is forced to bear full responsibility for all product-related injuries. Expecting to be fully compensated for their injuries in the future, consumers have no intrinsic reason to stop using the product. They will stop using the product, however, if they are compensated to stop. Consider a consumer with valuation v facing an offer from the manufacturer to buy the product back for a price p . If the consumer keeps the good, he derives value v from consumption. The consumer's valuation does not depend on the expected harm because the consumer is made whole under strict liability – any harm that the consumer suffers will be fully compensated.³⁴ It follows that the consumer would return the product to the manufacturer if and only if $v < p$.

The manufacturer receives a private benefit from a product buyback so long as the price paid for the return of the product, p , is less than the manufacturer's expected liability payments associated with that unit, h . The manufacturer chooses the buyback price p to simply minimize his expected future payments,

$$\text{Min } pG(p) + h[1 - G(p)] + \Delta.$$

³³ If the manufacturer learned information before selling the product, then the manufacturer would have an incentive to disclose that the product was safe in order to extract a higher sale price. See Polinsky and Shavell (2006).

³⁴ Note that this is true whether or not the consumer knows harm h when considering the return.

The first term represents the buyback payments to those consumers who choose to return the product, and the second term represents the expected liability payments to those consumers who do not comply with the recall and choose to retain and use the product. The third term is the fixed cost of contacting the consumers. Differentiation gives the following first-order condition:

$$[h - p^B]g(p^B) = G(p^B). \quad (4)$$

When the manufacturer raises the buyback price slightly the benefit is that it pays p^B instead of h to the marginal consumer who decides to return the product rather than continue to use it. The manufacturer's marginal benefit is therefore $[h - p^B]g(p^B)$. The manufacturer's marginal cost associated with the slightly higher buyback price is that he ends up paying a higher buyback price to consumers who would have sold the product back to the manufacturer at the lower price, $G(p^B)$. The buyback price equates the manufacturer's marginal benefit with the marginal cost.

Importantly, one can see that the buyback price p^B is typically less than the expected unit harm, h . The manufacturer is a *monopsonist*, a single buyer with market power when it comes to repurchasing its own products in order to avoid liability payouts. Just as a monopolist extracts profits from buyers by charging a price above marginal cost, our monopsonist manufacturer extracts rents from past consumers by offering a buyback price that is strictly less than the manufacturer's opportunity cost of not having the product returned, h .

Lemma 2: When $h \geq \underline{v}$ the manufacturer's best buyback price (if he chooses to do a buyback), $p^B(h)$, is the implicit solution to equation (4). In this range, $p^B(h)$ is strictly increasing in h with $p^B(\underline{v}) = \underline{v}$ and $p^B(h) < h$ for all $h > \underline{v}$. When $h < \underline{v}$ the manufacturer cannot benefit from a buyback (so $p^B(h) < \underline{v}$ and no buyers accept).

Proof: If $h < \underline{v}$ then the least a consumer is willing to accept, \underline{v} , exceeds the manufacturer's maximal willingness to pay, h . The manufacturer cannot profit from a buyback in this case and they will not arise in equilibrium. If $h > \underline{v}$ then the buyback price is implicitly defined by equation (4) above, or $p^B + G(p^B)/g(p^B) = h$. When $h = \underline{v}$, this equation is satisfied by $p^B = \underline{v}$. The monotone hazard rate assumption guarantees that the left hand side is an increasing function of p^B . Therefore $p^B(h)$ is increasing in h . ■

When the expected liability exceeds the valuation of the lowest consumer type, $h > \underline{v}$, the manufacturer may find it profitable to pay the fixed cost Δ to stage a product buyback. The manufacturer would pay a total of $p^B(h)G(p^B(h)) + h[1 - G(p^B(h))] + \Delta$ if he offers to buy the product back where $p^B(h)$ is implicitly defined in equation (4). If the manufacturer does not stage a buyback, the consumers will all continue to use the product and the manufacturer will pay a total of h . The manufacturer will therefore stage the buyback when

$$\Delta < [h - p^B(h)]G(p^B(h)). \quad (5)$$

Proposition 2: (Strict Liability with Product Buybacks.) Suppose that the manufacturer is held strictly liable for product injuries and can initiate a product buyback. There exists a cutoff, $h^B(\Delta)$, implicitly defined by:

$$[h^B(\Delta) - p^B(h^B(\Delta))]G(p^B(h^B(\Delta))) = \Delta, \quad (6)$$

where $h^B(\Delta)$ is an increasing function of Δ with $h^B(0) = \underline{v}$.

- (i) If $h \leq h^B(\Delta)$ then there is no buyback and all consumers continue to use the product.
- (ii) If $h > h^B(\Delta)$ then the manufacturer offers to buy the product back for $p^B(h)$ implicitly defined in (4) and consumers continue to use the product when $v \geq p^B(h)$.

Proof: Combining expressions (4) and (5), the manufacturer will stage a buyback when

$$\Delta < [h - p^B(h)]G(p^B(h)) = \left[\frac{G(p^B(h))}{g(p^B(h))} \right] G(p^B(h)) = \Psi(p^B(h)).$$

Let $h^B(\Delta)$ be the level of harm that satisfies this expression with equality, or

$$\Delta = \Psi(p^B(h^B(\Delta))).$$

Totally differentiating this expression and rearranging terms,

$$\frac{dh^B}{d\Delta} = \left(\frac{d}{dp^B}(\Psi(p^B)) \frac{d}{dh^B}(p^B(h^B)) \right)^{-1}.$$

The derivative of $\Psi(p^B)$ is positive because we assumed that the hazard rate, $G(v)/g(v)$, was monotone and the cumulative distribution function, $G(v)$ is of course monotone as well. The derivative of $p^B(h^B)$ is also positive by Lemma 2. Therefore we have that $h^B(\Delta)$ is an increasing function as well. When $\Delta = 0$ the manufacturer will stage a buyback for all $h > \underline{v}$ and, from the previous lemma, $p^B(\underline{v}) = \underline{v}$. We have $h^B(0) = \underline{v}$. ■

We will now prove that the private benefit to the manufacturer of staging a buyback is smaller than the social benefit when $h > \underline{v}$. The manufacturer's private benefit from the buyback is $[h - p^B(h)]G(p^B(h))$. The manufacturer saves $h - p^B(h)$ when a consumer returns the product, and the volume of returns is $G(p^B(h))$. We can write this private benefit as:

$$\int_{\underline{v}}^{p^B(h)} [h - p^B(h)]g(v)dv. \quad (7)$$

We will use this expression in a moment. There is an important externality at play: the manufacturer doesn't take consumer surplus into account when thinking about his private benefit of a buyback. A consumer with valuation $v < p^B(h)$ who returns the product gains consumer surplus of $p^B(h) - v$. The social gain from a buyback is the sum of producer and consumer surplus, $(h - p^B(h)) + (p^B(h) - v) = h - v$. Aggregated over all consumers who return the product, the social benefit of the product buyback is

$$\int_{\underline{v}}^{p^B(h)} (h - v)g(v)dv. \quad (8)$$

The social benefit of a product recall would be even higher if consumers with valuations between $p^B(h)$ and h stopped using the product. This does not happen because the firm is a monopsonist and so $p^B(h) < h$ for all $h > \underline{v}$ (by Lemma 2).

Proposition 3: (Strict Liability with Product Buybacks.) The manufacturer selects a buyback price that is too low and initiates a buyback too infrequently.

The decentralized market outcome with strict liability diverges from socially optimal behavior in two important respects. First, when buybacks are offered there are some consumers who continue to use the product even though it would be socially desirable for them to stop. This latter distortion arises because the buyback price is smaller than the expected harm, $p^B(h) < p^*(h) = h$. If instead the manufacturer were to set the buyback price equal to $p^*(h) = h$, the consumers would make the socially correct usage decision. Second, the manufacturer's private incentive to engage in a buyback is too small. The reason is simple: consumers benefit from the buyback *ex post* (since they have the option to return or keep the

product) and the manufacturer does not internalize the increase in consumer surplus that results from the buyback.³⁵ If a social planner fully controlled the recall process, he would contact consumers when $h > h^*(\Delta)$ and offer to buy the product back for $p^*(h) = h$ and the social welfare benchmark from Proposition 1 would be obtained.

³⁵ These ideas are familiar from the standard monopoly problem. There, a monopolist charges too high a price and fails to capture the consumer surplus. Consequently, a monopolist may decline to sink fixed costs of entry even when entry is socially efficient.

The Post-Sale Duty to Warn

Suppose that the court is well informed about the distribution of product harms and the nature of demand, and can design a liability rule that is sensitive to the manufacturer's realized information about harm, h .³⁶ If the court could accurately observe h *ex post*, then the court could implement the social welfare benchmark with a “duty to warn” requirement with a negligence standard $h^*(\Delta)$ defined in the social welfare benchmark equation (3). The manufacturer would not be held liable for product-related injuries if he discloses information to consumers (issues a post-sale warning). The manufacturer will be held liable, however, if he fails to warn consumers of the risks and, in addition, the court determines that $h > h^*(\Delta)$ (so a warning is cost-justified).

It is not hard to see why this rule leads to the socially correct consumer and producer behaviors. A consumer, believing that the manufacturer has complied with the standard, bears the full brunt of his own product-related injuries and therefore makes the socially correct consumption decision. This rule also gives the manufacturer the incentive to comply with the standard. Suppose that the manufacturer observes that the level of risk is just slightly above $h^*(\Delta)$, the duty-to-warn standard. The manufacturer prefers to disclose the risk to consumers rather than remain silent because his expected liability payments from non-disclosure are larger than the cost of disclosure, $h^*(\Delta) > \Delta$ (from Proposition 1). It follows that the manufacturer will comply with the standard when $h = h^*(\Delta)$ and will also comply with the standard when $h > h^*(\Delta)$ since the manufacturer's liability from not disclosing is increasing with his true type, h , but his costs remain fixed at Δ .

Proposition 4: (The Duty to Warn.) Consider the socially optimal threshold for disclosure, $h^*(\Delta)$, defined in Proposition 1. A negligence rule that imposes a duty to warn on the manufacturer when the product risk is above the threshold, $h > h^*(\Delta)$, but no such duty when the product risk is below the threshold, $h \leq h^*(\Delta)$, implements the social welfare benchmark.

³⁶ The court can potentially infer this harm level *ex post* by observing the prevalence and the magnitude of consumer injuries. If the manufacturer had private information about the aggregate probability of harm, however, then the realized harms are a very imperfect indicator of the information held by the manufacturer in the post-sale phase.

The post-sale duty to warn might be difficult to implement in practice for several reasons. First, it would require the court to determine “reasonable” behavior on the part of the manufacturer. In order to calculate $h^*(\Delta)$ the court would need to know the characteristics of consumer demand, $g(v)$, the cost of disclosure, Δ , and the manufacturer’s *ex post* observation of the parameter h . While some of these parameters may be roughly observable to a court, others would require a significant degree of expertise. Indeed, even managers of firms with direct knowledge and experience with the operations of the organization often find it difficult to quantify these factors. In practice, the court would need to rely on the evidence elicited through pretrial discovery and litigation, mechanisms that are imperfect.

Social Welfare Comparison

The next result follows immediately from the preceding analysis.

Proposition 5: (Comparison of Liability Regimes.) For any positive cost of disclosure, $\Delta > 0$, the post-sale duty to warn achieves higher social welfare than strict liability with product buybacks, which in turn achieves higher social welfare than having no liability at all.

5. Liability Rules and *Ex Ante* Investments in Product Safety

Up until this point, we have abstracted away from important *ex ante* issues in order to focus on the post-sale behavior of firms. In practice, liability rules will affect the prices that manufacturers can command for their products in the marketplace and their incentives to design safer products. While some hazards are beyond the control of manufacturers at the product design stage, other risks can be reduced through greater investments and precautions. Pharmaceutical companies, for example, invest in clinical testing before releasing drugs on the general market. Similarly, automobile manufacturers invest in crash testing their vehicles and other safety-related investigations. This section extends the analysis to explore the effect of liability rules on *ex ante* pricing and investment levels.

Suppose that before selling the product on the market, the manufacturer can invest resources $e \geq 0$ to reduce the probability, $\pi(e)$, that the product will be dangerous and cause harm $h \sim f(h)$. With probability $1 - \pi(e)$ the product will be perfectly safe and will cause no

harm at all, $h = 0$.³⁷ We will make the following assumptions to guarantee a nicely-behaved interior solution: $\pi'(e) < 0$, $\pi''(e) > 0$, $\pi'(0) = -\infty$, and $\lim_{e \rightarrow \infty} \pi'(e) = 0$. We assume further that these investments, e , are fully observable by consumers at the time of purchase. (This assumption will be discussed in greater detail later.) Since the manufacturer is a monopolist, and consumers are *ex ante* homogeneous with unit demand, the manufacturer can and will extract all expected consumer surplus through the sale price. As a consequence, the manufacturer's incentives at the *ex ante* stage to take precautions and invest in safety features are aligned with the interests of society more broadly.

No Manufacturer Liability

Suppose that the manufacturer bears no *ex post* responsibility for product injuries. Although the manufacturer has no incentive to stage recalls or warn consumers about product risks *ex post*, he does have an incentive to invest in product safety *ex ante*. Since consumers expect to bear the losses associated with accidents, consumers are willing to pay a premium for safer products. Formally, a consumer's willingness to pay for a product with safety investments e is $v_0 - \pi(e)h_0$. The manufacturer, as a monopolist, will extract this value through the price:

$$P^{NL}(e) = v_0 - \pi(e)h_0.$$

The manufacturer's costs include only the production costs and investments in safety. Since the manufacturer's mass of customers is normalized to 1, the total costs are

$$C^{NL}(e) = c + e.$$

The manufacturer's profits as a function of investment e are

$$\Pi^{NL}(e) = P^{NL}(e) - C^{NL}(e) = v_0 - c - e - \pi(e)h_0. \quad (9)$$

The manufacturer invests to the point where the marginal benefit of reduced expected accident harms is exactly equal to the marginal cost,

$$-\pi'(e^{NL})h_0 = 1. \quad (10)$$

³⁷ Formally, this is giving us a parameterization where distribution of harm with a mass point at $h = 0$ where the weight of that mass point is rising in the level of effort, e .

Strict Manufacturer Liability

With strict liability, a consumer's willingness to pay will actually exceed v_0 . A consumer with valuation v who continues to use the product will receive an *ex post* payoff of v . This is true whether or not there is an accident, since the consumer will be made whole through the liability system. If the product turns out to be sufficiently dangerous, however, then the manufacturer will offer to buy the product back for $p^B(h)$. Consumers with valuations $v < p^B(h)$ will return their products, thereby receiving a payoff that is higher than the gross valuation v . The manufacturer's price reflects the consumer's expected future rents:

$$P^{SL}(e) = v_0 + \pi(e) \int_{h^B(\Delta)}^{\infty} \int_{\underline{v}}^{p^B(h)} [p^B(h) - v] g(v) f(h) dv dh. \quad (11)$$

The second term, which is positive, is the expected consumer surplus associated with manufacturer buyouts. Intuitively, the consumer derives a benefit above and beyond their valuation, v , when $h > h^B(\Delta)$ and the manufacturer offers to buy the product back for a price $p^B(h) > v$. Note that the price in equation (11) is falling in the manufacturer's safety investments, e . That is, consumers pay less for products that are safer and more for products that are more dangerous. The manufacturer's total expected cost under strict liability is:

$$C^{SL}(e) = c + e + \pi(e)h_0 - \pi(e) \int_{h^B(\Delta)}^{\infty} \left(\int_{\underline{v}}^{p^B(h)} [h - p^B(h)] g(v) dv - \Delta \right) f(h) dh. \quad (12)$$

This may be understood intuitively. If product buybacks were infeasible, the manufacturer's costs would be $c + e + \pi(e)h_0$. When buybacks are feasible, however, the manufacturer enjoys some additional costs savings, captured by the last term in (12). Combining (11) and (12), the manufacturer's expected profits may be written as:

$$\Pi^{SL}(e) = P^{SL}(e) - C^{SL}(e) = v_0 - c - e - \pi(e)(h_0 - B^{SL}), \quad (13)$$

where

$$B^{SL} = \int_{h^B(\Delta)}^{\infty} \left(\int_{\underline{v}}^{p^B(h)} [h - v] g(v) dv - \Delta \right) f(h) dh \quad (14)$$

is the *ex post* social value from manufacturer-initiated buybacks.³⁸ The manufacturer will invest in safety precautions to the point where the marginal benefit of additional precautions equals the marginal cost,

$$-\pi'(e^{SL})(h_0 - B^{SL}) = 1. \quad (15)$$

The Post-Sale Duty to Warn

Now suppose that the courts can implement the post-sale duty to warn. As described earlier, this liability rule achieves the social welfare benchmark. The manufacturer warns consumers when $h > h^*(\Delta)$ and consumers make the appropriate usage decision and bear the harms from accidents. Given a level of investment e , the manufacturer can charge a price of:

$$P^*(e) = v_0 - \pi(e)h_0 + \pi(e) \int_{h^*(\Delta)}^{\infty} \int_{\underline{v}}^h [h - v]g(v)f(h)dv dh. \quad (16)$$

The last term is the value the consumer places on receiving future warnings from the manufacturer. When warned of harm h , consumers with valuations in the interval $[\underline{v}, h]$ stop using the product. Although the manufacturer avoids liability for the product-related harms, the manufacturer does bear the fixed costs of issuing warnings. The manufacturer's total cost is:

$$C^*(e) = c + e + \pi(e) \int_{h^*(\Delta)}^{\infty} \Delta f(h)dh. \quad (17)$$

Taken together, the manufacturer's profits are

$$\Pi^*(e) = V^*(e) - C^*(e) = v_0 - c - e - \pi(e)(h_0 - B^*), \quad (18)$$

where

$$B^* = \int_{h^*(\Delta)}^{\infty} \left(\int_{\underline{v}}^h [h - v]g(v)dv - \Delta \right) f(h)dh \quad (19)$$

is the social value generated by the post-sale duty to warn. The manufacturer will invest in safety precautions up to the point where

$$-\pi'(e^*)(h_0 - B^*) = 1. \quad (20)$$

³⁸ Recall that buybacks are socially valuable because $h - v$ is avoided when consumers with values $v < p^B(h) < h$ return their products to the manufacturer.

Social Welfare Comparison

Given the preceding characterizations, it is straightforward to rank the three regimes in terms of product safety investments and the manufacturer's profits. The social welfare is identical to the manufacturer's profits since investments are observable to consumers and the manufacturer fully extracts consumer surplus *ex ante* through the sale price.

Proposition 6: $e^{NL} > e^{SL} > e^*$ and $\Pi^{NL}(e^{NL}) < \Pi^{SL}(e^{SL}) < \Pi^*(e^*)$.

At first glance, it may be surprising that a regime of no liability leads to greater investments in safety than the other regimes. This arises because consumers demand safer products *ex ante*, since they anticipate (rationally) that they will never be warned when products are dangerous *ex post* and therefore will suffer greater *ex post* harms. The manufacturer's greater *ex ante* investments in product safety serve as a substitute for *ex post* warnings and buybacks. When there is a post-sale duty to warn, consumers can rest assured that they will be appropriately notified *ex post* that products are dangerous. This implies that consumers place a smaller premium on safer products *ex ante*, and so the manufacturer invests less in safety.

The post-sale duty to warn leads to the highest possible social welfare, followed by the regime of strict liability, followed by no manufacturer liability at all. Formally, the manufacturer's profits or (equivalently) social welfare are the maximized value of $\Pi^j(e) = v_0 - c - e - \pi(e)(h_0 - B^j)$ where $j = *, SL, NL$ is the liability regime. Since the constants $B^* > B^{SL} > 0$ we can apply the envelope theorem to verify that $\Pi^*(e^*) > \Pi^{SL}(e^{SL}) > \Pi^{NL}(e^{NL})$. It is not surprising the post-sale duty to warn performs so well. We established earlier that this rule leads to the socially optimal *ex post* disclosure decision for the manufacturer and socially optimal decision rule for the consumers. Furthermore, since the manufacturer fully extracts consumer surplus at the *ex ante* stage, the manufacturer's investments in product safety are socially optimal as well. It bears repeating, however, that the information demands on the court may well prevent the accurate implementation of this rule in practice. Strict liability, while not achieving the social welfare benchmark, may be a viable second-best solution.

Discussion

This analysis in this section relied on the assumption that safety investments, e , were perfectly observable to consumers at the time of the original sale. Our results would still hold if e were privately observed by the manufacturer, assuming that it could be costlessly and credibly disclosed to consumers. Suppose that there is no manufacturer liability. As described above, the price that consumers are willing to pay is increasing in their beliefs about product safety. A manufacturer who has sunk costs to create a very safe product would have an incentive to disclose that information to consumers, thereby receiving a higher price. The negative inferences made by consumers when the manufacturer is silent would put pressure on the manufacturers of less safe products to disclose the product's harm as well. In the absence of manufacturer liability, all of the information would come to light and the manufacturer's price would perfectly reveal the harm to consumers. This is, of course, the traditional unravel argument (see Grossman, 1981; Verrechia, 1983; Shavell, 1994; Polinsky and Shavell, 2006).³⁹

This discussion highlights a fundamental difference between information known by the manufacturer at the time of a sale and information that is only discovered later after the product has been sold. Even in the absence of liability, the economic incentives created by the market encourage the manufacturer to disclose information prior to a sale.⁴⁰ When harms are discovered by the manufacturer only after the product has been sold, however, these fundamental market incentives are missing. When product risks are discovered only after the sale of the product, manufacturer liability is necessary to create incentives for disclosure.

Unraveling arguments also apply when the manufacturer is held strictly liable for product related injuries, although (interestingly) the logic of unraveling goes in the opposite direction. With strict liability, consumers are willing to pay more for unsafe products. Consumers are made whole *ex post*, and may do even better than that when the manufacturer initiates a buyback. A manufacturer who has created a very unsafe product therefore has an incentive to disclose that fact to consumers *ex ante*, thereby securing a higher price. The consumers would interpret silence on the part of the manufacturer as reflecting higher levels of product safety. This leads

³⁹ A similar argument can be made for the post sale duty to warn since consumers directly value safer products in that regime as well.

⁴⁰ Full disclosure may be compromised by a variety of factors. Disclosure costs, for example, can lead to partial pooling outcomes. See Polinsky and Shavell (2006).

manufacturers with somewhat higher levels of safety investments to disclose as well. In the end, if disclosure is costless then all information is revealed and our previous results obtain.

Our analysis would surely change if investments in product safety could not be credibly disclosed to consumers at the time of the sale.⁴¹ In this case, the post-sale duty to warn provides at best weak incentives for product safety. The social cost of a harmful product includes both the harms to the consumer, h , and the costs to the manufacturer of staging the recall, Δ . Under the post-sale duty to warn, the manufacturer bears the latter cost *ex post* but not the former (since liability is averted when the manufacturer discloses information to consumers). This suggests that the manufacturer may take suboptimal precautions to reduce the incidence of harm at the *ex ante* stage. Strict liability may provide better incentives than the post-sale duty to warn in this case. Product buybacks are *ex post* costly for the manufacturer (since they pay both the fixed costs, Δ , and a price to consumers to return the product) and this creates an incentive to design safer products to begin with. It should be made clear, however, that strict liability falls short of full social efficiency. The improved *ex ante* deterrence is coupled with the very same *ex post* distortions identified earlier.

If society is concerned that manufacturers are investing too little in precautions to reduce the future harms caused by their products, then it would make sense to adopt additional instruments to encourage these investments. Regulations that mandate product testing (as in the automobile and pharmaceutical industries) or negligence rules for *ex ante* care levels would be valuable supplements to the post-sale duties analyzed in this paper. A full formal analysis of privately observed safety measures is beyond the scope of this manuscript.

6. Conclusion

This paper considered the problem of encouraging manufacturers to adequately warn consumers of product dangers, while at the same time encouraging consumers to make prudent decisions about continuing to use dangerous products. Under a regime of strict liability, the manufacturer may find it profitable to contact consumers and offer to repurchase the product. By

⁴¹ The analysis would be more subtle if there were downward sloping demand. There, the manufacturer's *ex post* costs would effect the monopoly price. Consequently, the price charged by the monopolist would be a signal of product safety. See Daughety and Reinganum's (1995) analysis of liability and price signaling and Daughety and Reinganum (2008a) and (2008b) on the choice between signaling and disclosure when there are disclosure costs.

doing so, the manufacturer can avoid the future liability associated with product injuries. Although this regime performs better than having no liability at all, the private incentives of the manufacturer fall short of the social welfare benchmark. The manufacturer does not internalize the surplus that his buyback creates for consumers, and therefore does not stage a recall often enough and makes a buyback offer that is too low. A negligence-based duty to warn, where the manufacturer is held liable if and only if he fails to take cost-justified measures, achieves the social welfare benchmark but may be difficult to implement. The effects on *ex ante* pricing and safety investments were also explored.

Future research on this topic might explore the efficacy of other legal instruments as well. Punitive damages – a key issue in the lawsuits brought against Merck for their painkiller Vioxx – have the potential to be helpful in certain circumstances.⁴² Suppose that there is a post-sale duty to warn, but detection is imperfect and so the manufacturer may succeed in avoiding liability when he fails to warn consumers. In this case, punitive damages can restore the manufacturer's incentives to comply with the negligence standard. In a similar vein, a damage multiplier can help to raise a manufacturer's incentives to initiate a product recall under strict liability. This may be valuable when plaintiffs have a difficult time establishing a link between their injuries and the manufacturer's product, or when plaintiffs have an otherwise insufficient incentive to bring their claims.⁴³ Alternatively, the rule of strict liability might be augmented with a warning defense, where manufacturers can avoid liability for product harms by disclosing the products risks *ex post*.⁴⁴ This rule has the advantage that consumers, once warned, bear the costs of accidents and therefore have the incentive to discontinue product use when the harm exceeds their private benefit. On the downside, a warning defense could lead the manufacturer to contact

⁴² Punitive damages may be awarded in cases involving gross negligence and willful misconduct. In recent Vioxx litigation against Merck, a punitive damages award by a lower court was struck down on appeal (Berenson, 2008).

⁴³ See Shavell (2004) for a discussion of punitive damages in law. A damage multiplier would not, however, lead the manufacturer to choose an appropriate buyback price. Although the benefit to the manufacturer of removing the product from use is higher, suggesting that the buyback price will rise, the consumers will demand correspondingly higher prices to compensate them for the foregone opportunity to sue.

⁴⁴ In practice, issuing warnings and staging recalls can also protect manufacturers against punitive damages claims. Jewel Companies, Inc. , for example, “avoided a punitive damages award because of the remedial actions it took after receiving notice of a salmonella outbreak, instituting an immediate recall program, hiring a private lab to inspect its plants and test its products, ...” Ross (2004, p. 85).

consumers too frequently.⁴⁵ Finally, one might argue that regulatory agencies could be given greater latitude to influence recall decisions and buyback prices.

This paper abstracted from the effect of product recalls on the future sales and activities of manufacturers. When products are long-lived and the quality of products is correlated over time, the decision of a manufacturer to recall a product can have the long run effect of chilling demand for the manufacturer's product and potentially encouraging additional lawsuits that otherwise would not have been brought (as in Ben-Shahar, 2005). It would be interesting to model these future reputational concerns in addition to the corrective benefits of product recalls considered here. Another important issue is the manufacturer's decision to repair existing dangerous products or to replace them with new products rather than to simply repurchase them.⁴⁶ These issues are beyond the scope of the current manuscript and left for future research.

⁴⁵ An analysis of this regime as included in a previous working paper version of this paper available from the author upon request.

⁴⁶ Hua (2009) considers a model of product recalls where the manufacturer learns about the probability of harm following the sale of the product, and consumers learn about the magnitude of the harm. He considers different rules governing the consumers' duty to return the product to the manufacturer and their effect on the manufacturer's incentives to fix or replace the product.

7. Appendix

Proof of Proposition 1: Using the expression for social welfare in (1) and the results in Lemma 1, the values h_{ND} , \underline{h} , and \bar{h} maximize,

$$\begin{aligned} & \int_0^{\underline{h}} \int_h^\infty (v-h)g(v)f(h)dv dh + \int_{\underline{h}}^{\bar{h}} \int_{h_{ND}}^\infty (v-h)g(v)f(h)dv dh \\ & + \int_{\bar{h}}^\infty \int_h^\infty (v-h)g(v)f(h)dv dh - [1-F(\bar{h})+F(\underline{h})]\Delta - c, \end{aligned}$$

subject to the constraint that $0 \leq \underline{h} \leq \bar{h}$. Differentiating with respect to h_{ND} and setting the expression equal to zero verifies that $h_{ND} = E(h | h \in [\underline{h}, \bar{h}])$. Differentiating with respect to \underline{h} and dividing by $f(\underline{h})$,

$$\int_{\underline{h}}^{h_{ND}} (v-\underline{h})g(v)dv - \Delta.$$

This expression is weakly decreasing in \underline{h} . Evaluating it at $\underline{h} = 0$ gives

$$\int_0^{h_{ND}} vg(v)dv - \Delta \leq \int_0^{h_0} vg(v)dv - \Delta \leq -\Delta < 0.$$

This first inequality follows from the fact that $h_{ND} = E(h | h \leq \bar{h}) \leq h_0$ and the second equality follows from Assumption 1. Moreover, since it is strictly smaller than 0 when $\underline{h} = 0$, then it must be strictly smaller than 0 for all $\underline{h} > 0$. Therefore we have a corner solution, $\underline{h} = 0$. The first-order condition for \bar{h} is

$$\int_{\bar{h}}^{\bar{h}} (\bar{h}-v)g(v)dv = \Delta.$$

Since $h_0 \leq \underline{v}$ by Assumption 1, we know that $h_{ND} \leq h_0 \leq \underline{v}$ and so this condition becomes $\int_{\underline{v}}^{\bar{h}} (\bar{h}-v)g(v)dv = \Delta$ and we denote the implicit solution to be $h^*(\Delta) > \Delta$. ■

8. References

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